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Seismic Analysis of Asymmetry Multi-Storied Structures Using Dynamic Analysis Method in Bangladesh

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Abstract

Structural response against seismic actions has been a prime issue nowadays. It is quite a dominant parameter while various infrastructures are growing vastly, specifically in the higher seismic-prone areas. Various asymmetrical configurations are attempted according to current architectural requirements where structural irregularities become one of the main concerns. It can be either or both geometric or vertical irregularity. In such cases, static as well as dynamic response analysis of multi-storied structures is necessary to analyze story displacement, story drift, base shear, and torsional irregularity. As stated by the Bangladesh National Building Code (BNBC-2020), the current study's goal is to evaluate the seismic demand of symmetric and asymmetric structures to evaluate stiffness, adequate lateral strength, ductility, and some other factors. This study examined models with different configurations (T-shaped, L-shaped, and Plus-Shaped) of G+20 in different zones of Bangladesh. The buildings were modeled using ETABS-2016 (Extended Three-Dimensional Study of Building System). Linear dynamic analysis was conducted using the Response Spectrum Analysis method on the modeled structures. The results show that irregular or asymmetric structures show more structural irregularities than regular structures. Consequently, irregular structures in areas with higher seismic zone coefficients are more vulnerable to seismic actions.

Keywords: *Structural irregularity; multi-storied; ETABS; response spectrum analysis; and BNBC-2020.*

1 Introduction

For aesthetic purposes, buildings are frequently designed with irregular geometries and elevations in the present day. In addition to economic feasibility, land availability, and other considerations, these irregularities can also be attributed to other factors (Kakade, 2018). Recent earthquake studies indicate that structures with regular configurations fare better in seismic events, whereas those with irregular configurations struggle to withstand the impact (Raagavi & Sidhardhan, 2021). During an earthquake, structures experience lateral deflections due to the seismic impacts that are applied. Statistical knowledge of seismicity, historical earthquakes, and the region's tectonic configuration should be studied to identify earthquake-prone areas in a particular country (Kalkan & Selection, 2015). In this field, numerous investigations have been conducted.

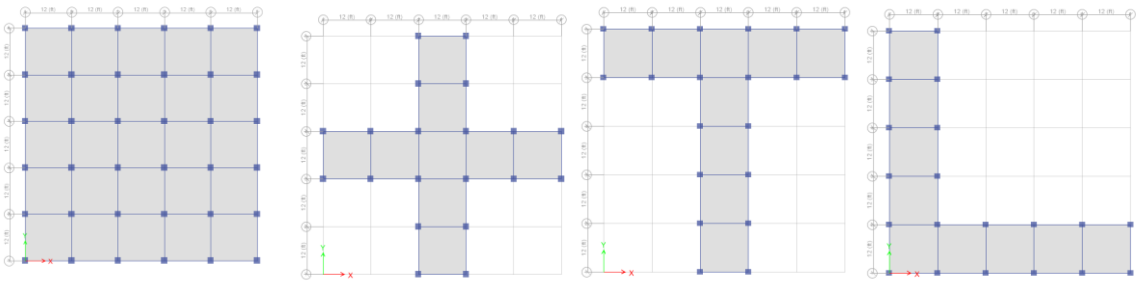
According to Shohag and Mozumder (Raisul et al., 2022), who studied H-shaped, L-shaped, and rectangular-shaped buildings, L-shaped structures are more cost-effective. Recent and past developments in the field of seismic analysis on symmetry and asymmetry shaped building frames were investigated by Anmol Deep Bagde & Umank Mishra (Bagde, 2022). According to the Bangladesh National Building Code (BNBC, 2006), Zasiah Tafheem et el, Johinul Islam Jihan, Tameem Samdanee, Md. Zahidul Islam & Abu Syed Md. Tarin (Tafheem et al., 2016) investigated the seismic performance of a multistory reinforced concrete moment-resisting frame building under static and dynamic loading. Sabahat J. Ansari & Dr. S. D. Bhole (Ansari, 2016) analyzed the seismic performance of torsionally balanced and unbalanced buildings, also known as symmetric and asymmetric buildings. It is concluded that the performance of models in which the rigidity of plan size is accounted for is superior to that of models in which the stiffness of plan size is neglected. Chimpula Rajashekar Reddy & Mr. Mothilal (Reddy et al., 2023) utilised the ETABS software to analyze a G+15 RCC structure with an irregular plan. This study's primary objective is to examine the behavior of the structure by determining various parameters, such as story displacements, story drifts, and story shears among others. Pardeshi Sameer and Prof. N. G. Gore (Pardeshi sameer, 2016) studied seismic analysis and design of multi-storey symmetrical

and asymmetrical buildings. They found that large displacement was observed in the T shape building. It indicates that building with severe irregularity shows maximum displacement and storey drift. Neelavathi et al. (Neelavathi et al., 2019) analyzed a 20-story RC building with 5 models of distinct regular and irregularly shaped structures subjected to earthquake stress and modeled with ETABS version 9 software.
The literature cited above reveals deficiencies in the work conducted across all zones. This study aims to investigate the effect of geometry and configuration of structures on the different seismic zone in Bangladesh (Kabir et al., 2015). The BNBC 2020 classified Bangladesh into four seismic zones based on different factors: Zones I, II, III, and IV. Zone- IV is the most seismically active region, while Zone-I is the least active. The objective of preserving a uniform weight for each case dictates the selection of various models with varying shapes and corresponding dimensions in different seismic regions.

2 Methodology

2.1 Structural Plan

In the context of G+20-story structures, it is notable that there exists four distinct building shapes within each of the four designated zones. These shapes include the square, plus, T, and L shapes. Figures 1 and 2 provide visual aids in elucidating the plan and elevation view, respectively.



(a) (b) (c) (d)

Figure 1. Plan view of G+20 buildings (a) Square shaped (b) Plus shaped (c) T-shaped (d) L-shaped

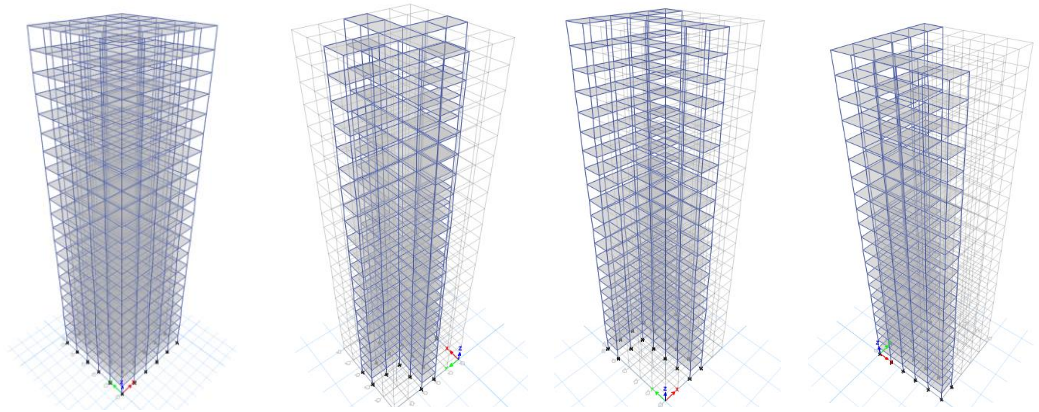


Figure 2. 3D view of G+20 buildings (a) Square shaped (b) Plus shaped (c) T-shaped (d) L-shaped

2.2 Model Details

Table 1 displays the material's characteristics along with a brief summary of the models.

Table 1. Summary of model description and material properties

Model Properties		Material Properties	
Provided B/L Ratios	B/L = 1	Material Type	Concrete
Breadth of Model	60’	Comprehensive Strength of Concrete	4000 psi
Column Size	17 " × 17 "	Weight per Unit Volume	150 pcf
Ground Column	19 " × 19 "	Modulus of Elasticity (E)	3.65×10^6 psi
Floor Beam	14 " × 20 "	Shear Modulus of Concrete (G)	1502 psi
Grade Beam	16 " × 22 "	Yield Strength of Steel	60,000 psi
Slab Thickness	5 "	Soil Type	SC
Shear Wall Thickness	8 "	SPT	15-50
Interior Wall	5 "		
Exterior Wall	10 "		
Occupancy Category	II		
Exposure Category	B		

2.3 Method of Analysis

The models were examined using ETABS-2016 software. In the current study, the response spectrum method for dynamic analysis was employed. According to BNBC 2020, all loadings and other parameters were completed.

3 Results and Discussion

3.1 Storey Displacement

The L-shaped structures in zone 4 experienced the highest degree of displacement due to their relatively lower level of symmetry in comparison to other structures. According to Figure 3, the L-shaped structure exhibits nearly five times greater displacement than the square shaped structure. As the irregularity of the building plan increases, there is a corresponding increase in both the displacement and drift of each storey. Figure 4 displays the zonal displacement of the four shapes within a G+20 building. The square and plus shaped structures exhibit nearly identical displacement patterns in distinct regions. Conversely, there is an upward trend in the displacement of T-shaped and L-shaped structures as one moves from zone 1 to zone 4. Research has indicated that structures with T and L shapes exhibit a higher degree of vulnerability.

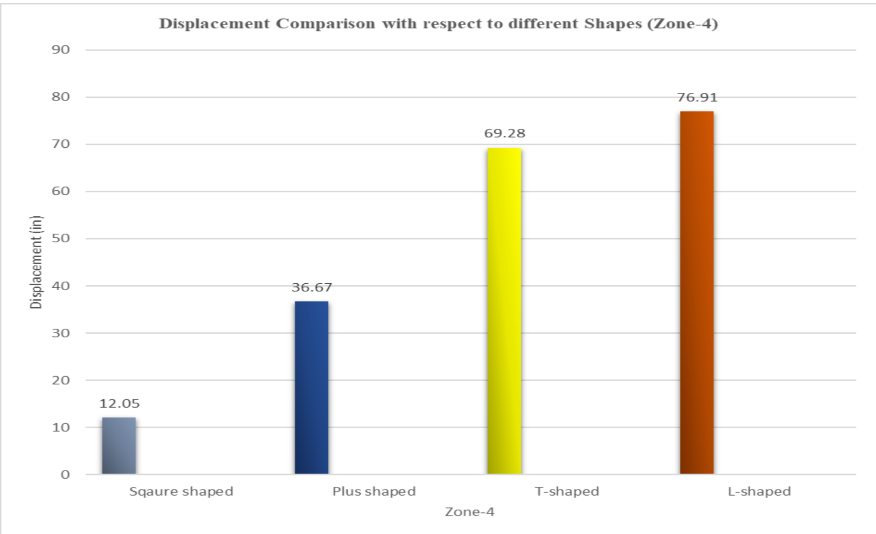


Figure 3. Displacement Comparison with Respect to Different Shapes (Zone-4)

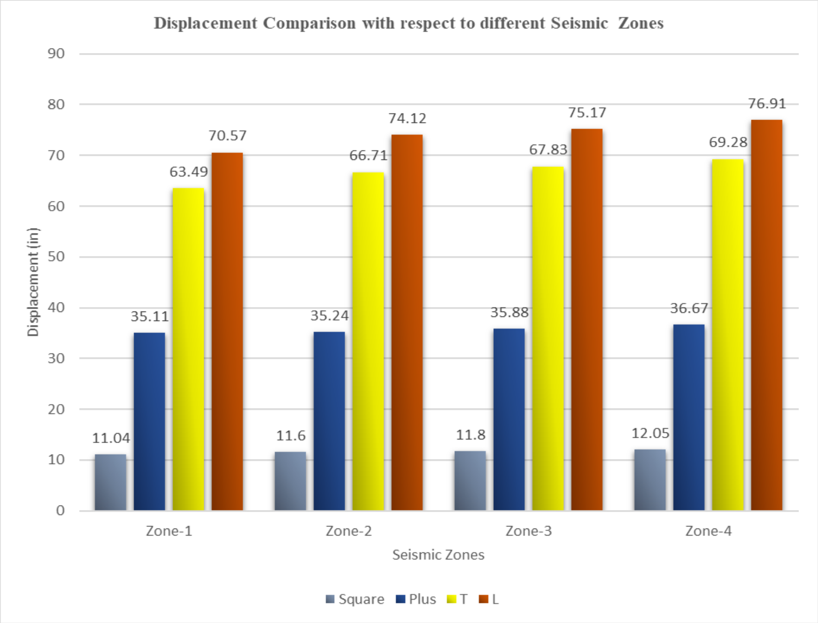


Figure 4. Displacement Comparison with Respect to Different Seismic Zones

3.2 Storey Drift

Based on the findings presented in Figure 5, it can be concluded that the L-shaped building exhibits the highest storey drift under dynamic earthquake load, while the square-shaped building experiences the lowest storey drift. According to Figure 6, there is a positive correlation between the drift and the zone, as the latter increases, the former also increases.

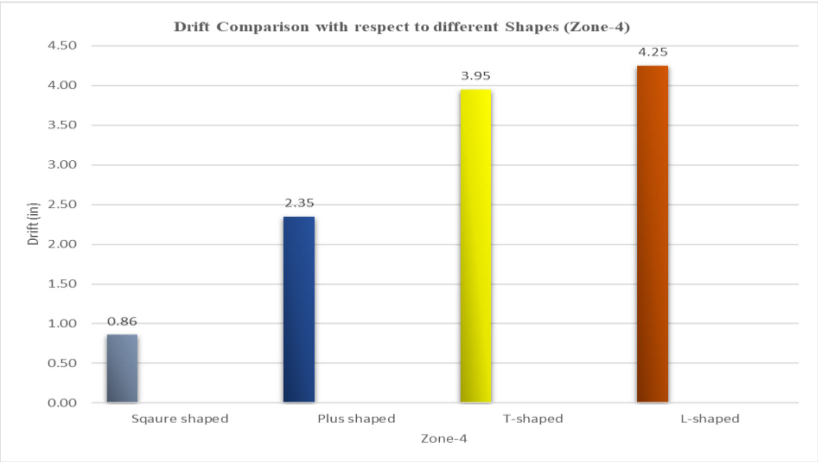


Figure 5. Drift Comparison with Respect to Different Shapes (Zone-4)

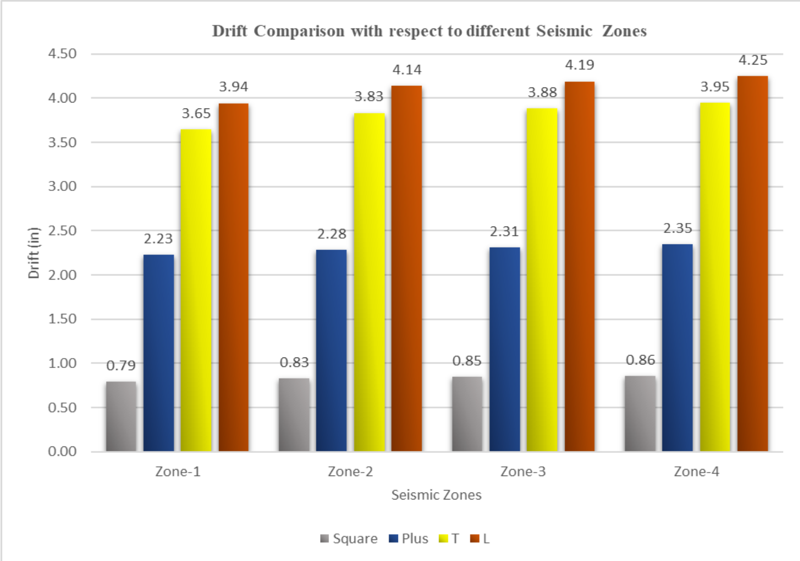


Figure 6. Drift Comparison with Respect to Different Seismic Zones

4 Conclusions

1. Drift and deflection of high-rise structure should be considered in areas with higher seismic zone coefficient due to notable magnitude.
2. The seismic response of a building is influenced by various factors such as its stiffness, strength, ductility, and particularly its structural configuration.
3. Structures that exhibit irregularities in their design are frequently subjected to significant damage during seismic events.
4. Significant displacement was detected in the L-shaped structure. The findings suggest that structures exhibiting significant irregularities tend to experience greater levels of displacement and storey drift.

References

Kakade, D. N. (2018). Comparative Seismic Analysis of Irregular Shaped Multi Storied Structure With and Without Infill. July.

Raagavi, M. T., & Sidhardhan, S. (2021). A Study on Seismic Performance of Various Irregular Structures. International Journal of Research in Engineering and Science (IJRES) ISSN, 9(5), 12–19. www.ijres.org

Kalkan, E., & Selection, G. (2015). SEISMIC EVALUATION OF EXISTING MULTI STOREY REINFORCED CONCRETE by B . S . in C . E ., Middle East Technical University , 1998 Submitted to the Institute for Graduate Studies in Science and Engineering in partial fulfillment of the requirements for the de. January 2001

Raisul, J. M., Shohag, I., & Mozumder, K. (2022). Raisul Islam Shohag, Kowshik Mozumder. Performance Assessment of Residential Building for Different Plan Configurations in Different Seismic Zones of Bangladesh Using ETABS. Journal of Civil, Construction and Environmental Engineering, 7(5), 93–101. https://doi.org/10.11648/j.jccee.20220705.12

Bagde, A. D. (2022). Discussion on Recent and Past Development in the Field of Seismic Analysis on Symmetry and Asymmetry Shaped Building Frames. International Journal for Research in Applied Science and Engineering Technology, 10(7), 4854–4858. https://doi.org/10.22214/ijraset.2022.46088

Tafheem, Z., Jihan, J. I., Samdanee, T., Syed, A., & Tarin, M. (2016). EARTHQUAKE RESPONSE ANALYSIS OF A MULTISTORIED RC BUILDING UNDER EQUIVALENT STATIC AND DYNAMIC LOADING AS PER BANGLADESH NATIONAL BUILDING CODE 2006. In Malaysian Journal of Civil Engineering (Vol. 28, Issue 1).

Ansari, S. J. (2016). Comparative Study of Symmetric & Asymmetric L- Shaped & T-Shaped Multi-Storey Frame Building Subjected to Gravity & Seismic Loads with Varying Stiffness. 2(10), 734–742.

Reddy, C. R., Mothilal, M., & Reddy, C. R. (2023). Comparative Study on G + 15 RCC Building with Plan Irregularity Using Response Spectrum Comparative Study on G + 15 RCC building with plan irregularity using Response Spectrum Analysis and Time History Analysis.

Pardeshi sameer, P. N. G. G. (2016). Study of seismic analysis and design of multi storey symmetrical and asymmetrical building. International Resesarch Journal of Engineering and Technology, 1893, 732–737.

Neelavathi, S., Shwetha, K. G., & Mahesh Kumar, C. L. (2019). Torsional behavior of irregular rc building under static and dynamic loading. Materials Science Forum, 969 MSF(November), 247–252. https://doi.org/10.4028/www.scientific.net/MSF.969.247

Kabir, R., Sen, D., & Islam, M. (2015). Response of multi-storey regular and irregular buildings of identical weight under static and dynamic loading in context of Bangladesh. 5(3), 252–260. https://doi.org/10.6088/ijcser.2014050024

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